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GENERAL EDITOR

SECTION A

CHEMICAL AND GEOLOGICAL SCIENCES AND THE INDUSTRIES

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THE PHILIPPINE

JOURNAL OF SCIENCE

A. CHEMICAL AND GEOLOGICAL SCIENCES
AND THE INDUSTRIES

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DATURA ALBA[1]

By HARVEY C. BRILL

(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

In connection with a survey of the medicinal plants of the Philippine Islands the Bureau of Science has had occasion to examine the various portions of the plant *Datura alba*[2] for its alkaloid content and to investigate the effects of drying on its content.

Table I describes the condition of the material when examined, the methods of drying and extracting, and the results.

TABLE I.—*Description of material, methods of drying and extracting of Datura alba, and results obtained.*

Description of material.	Method of drying.	Method of determining.	Total alkaloid.[a]
			Per cent.
Mature seeds	Sundried	According to Autenrieth[b]	[c]0.405
Do	Washed in water and then dried on a board in the shade.	do	[c]0.461
Do	Partially dried in shade; finished in large flat dish in sun.	do	[c]0.504
Do	Partially dried in shade; finished on paper in sun.	do	[c]0.561
Do	Dried on gas range in 4 hours	do	0.351
Green leaves	Not dried	Modification of Autenrieth	0.375
Stems	do	do	0.440

[a] Calculated to dry weight.

[b] Autenrieth-Warren, Detection of Poisons. P. Blakiston's Son & Co., Philadelphia, Pa., 4th ed. (1915), 293.

[c] The average of several determinations.

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[1] Received for publication September, 1916.

[2] For a discussion of its occurrence and use in the Philippine Islands and references to the literature pertaining to it, see Bacon, *This Journal, Sec. A* (1906), 1, 1019.

TABLE I.—*Description of material, methods of drying and extracting of Datura alba, and results obtained*—Continued.

Description of material.	Method of drying.	Method of determining.	Total alkaloid.
			Per cent.
Flowers	Not dried	Modification of Autenrieth	0.450
Immature fruit	do	do	0.409
Pods from preceding.	do	do	0.022
Nearly mature fruit.	do	do	0.325
Mature seeds	do	do	0.537
Mature fruit	do	do	0.380
Mature pods	do	do	0.076
Green leaves	Ground and then dried at 90–100° C.	According to Autenrieth	0.243
Stems	do	do	0.183
Flowers	do	do	0.248
Immature seeds	do	do	0.248
Immature fruit	do	do	0.275
Pods from preceding.	do	do	0.081
Mature seeds	do	do	0.393
Mature fruit	do	do	0.038
Mature pods	do	do	0.327
Green leaves	Dried in steam oven. Allowed to remain for several days after becoming dry.	do	0.108
Do	do	do	0.114
Stems	do	do	0.032
Flowers	do	do	0.171
Immature fruit	do	do	0.131
Mature fruit	do	do	0.175
Mature seeds	do	do	0.266
Green leaves	do	10 grams material treated with 50 cc. H_2O and 0.5 cc. HCl and warmed on steam bath, filtered, evaporated to small bulk, and treated as in preceding.	0.069
Flowers	do	do	0.205
Immature fruit	do	do	0.160
Mature fruit	do	do	0.198
Mature seeds	do	do	0.217
Immature fruit	do	10 grams material in 50 cc. alcohol, evaporated to dryness at low temperature after being made acid, and then treated as above.	0.134
Do	do	Same as above except made alkaline with NH_4OH.	0.052
Do	do	Same, except made acid with HCl.	0.147

TABLE I.—*Description of material, methods of drying and extracting of Datura alba, and results obtained*—Continued.

Description of material.	Method of drying.	Method of determining.	Total alkaloid.
			Per cent.
Immature fruit	Dried in steam oven. Allowed to remain for several days after becoming dry.	10 grams material in 50 cc. H_2O acidified with HCl and heated, filtered, extracted with fuller's earth, and filtered.[d] Extract made alkaline and treated as preceding.	0.094
Green leaves	Dried in desiccator over KOH	According to Autenrieth	0.406
Flowers	do	do	0.489
Mature seeds	do	do	0.589
Mature pods	do	do	0.067
Green leaves	Dried in air on floor of room. Time about two weeks.	do	0.234
Stems	do	do	0.251
Immature fruit	do	do	0.262
Immature fruit. This fruit had become somewhat moldy.	do	do	0.222
Green leaves	do	By use of fuller's earth, see above.	0.210
Stems	do	do	0.208
Immature fruit	do	do	0.231

[d] Japanese fuller's earth used in this extraction and the plant material used were given to us by Mr. Dean C. Worcester. For discussion of the use of hydrous aluminium silicate in the extraction of alkaloids, see Lloyd, John Uri, *Journ. Am. Phar. Assoc.* (1916), 5, 381.

DISCUSSION OF RESULTS

The flower heads of *Datura alba* grown in China are reported[3] to contain 0.485 per cent of alkaloid calculated as hyoscine. A. R. K. Dohme[4] states that the fresh parts in general contain more than the dried parts; that the stems contain the most alkaloid, the seeds next, then the leaves, and the roots least of all. I have found the various parts to range in the following order: Mature seeds, flowers, stems, immature fruit, and leaves. These experiments show that prolonged drying and heating at high temperatures cause a loss of the alkaloid; that the alkaloid is more readily extracted from the material by alcohol in an acidified suspension than in either a neutral or alkaline; and that a possible commercial method is to grind the raw material finely, treat it with hot acidified water, and then treat this extract with fuller's earth. By extracting this earth with alcohol after it has been made alkaline, a concentrated solution of the alkaloid in alcohol can be made. The alkaloid is somewhat soluble in neutral water. The fuller's earth used in these experiments was not very active. It enabled me to extract from 66 to 90 per cent of the alkaloid by using relatively large quantities of the earth. A more active variety should be used in order that the bulk may be kept small. This active variety can either be obtained from Professor Lloyd or prepared by the methods described[5] by him. He was able to secure practically complete absorption by the use of eight parts of the hydrous silicate to one part of the alkaloid.

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[3] U. S. Dispensatory, 18th ed., 1290.

[4] Ibid.

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[5] *Journ. Am. Phar. Assoc.* (1916), **5**, 381.

SOME PHILIPPINE TANBARKS [1]

By VICENTE Q. GANA

(From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.)

As far as I am aware, mangrove bark, camanchili bark, and alum are the only tanning materials utilized in the Philippine Islands at present. The blending of different barks is not being practiced here, and until more is known of the tanning qualities of the available materials, it will not be possible for the Filipino tanners to produce combination tannages like those used in Europe and in the United States.

At present the mangrove swamps, which constitute 2 per cent of the public forests of the Philippine Islands, or 207,200 hectares,[2] are considered the most important source of Philippine tan material, not only on account of the abundance of the mangrove trees, but also because of the fair amount of tannin in the bark. The tannin content and the tanning qualities have been already investigated.[3] The bark, when used [4] alone, produces a leather which is harsh and dark red in color; it is almost unsalable. Cox [5] found that the available heating value of the combustible matter [wood − (water + ash)] in the air-dried bark of six species of mangrove averages 4,625 calories. Although these results were obtained from fresh bark and not from spent tanbark, it is obvious that the waste material should be found useful in steam and power production at the tannery.

Camanchili (*Pithecolobium dulce* Bentham) bark comes next in importance and is used to some extent by the majority of Filipino tanners. It has little coloring matter and produces a dull, light brown leather. Due to the presence of nitrogenous compounds [6] an infusion of the bark very soon ferments and develops a disagreeable odor.[7] In using camanchili bark in a warm climate, antiseptics should be added to the infusion to check excessive fermentation.

With the object of rendering more materials available to the

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[1] Received for publication May, 1916.

[2] *Bull. P. I. Bur. Forestry* (1911), No. 10, 17.

[3] Bacon, R. F., and Gana, V. Q., *This Journal, Sec. A* (1909), 4, 205. Williams, R. R., ibid. (1911), 6, 45.

[4] Ibid. (1911), 6, 45.

[5] Cox, Alvin J., ibid. (1912), 7, 8.

[6] Ibid. (1915), 10, 366.

[7] In France a root bark of *Quercus coccifera*, called "garoville," has the same disadvantage.

tanning industry, the Bureau of Science has undertaken this investigation of the barks of some of the common trees of the Philippine Islands that may have tanning properties. The results obtained with the following barks have already been published.[8]

Common name.	Botanical name.
Cateban and ulayan.	*Quercus* sp.
Balinghasay.	*Buchanania arborescens.*
Pagsahinging.	*Canarium villosum.*
Calamansanay.	*Nauclea calysina.*
Ligas.	*Semicarpus accuminatissima.*
Sacat fruits.	*Terminalia nitens.*

The present work deals with the barks of the following trees:

Common name.	Botanical name.
Pine.	*Pinus insularis.*
Narra.	*Pterocarpus vidalianus.*
Palo maria.	*Calophyllum inophyllum.*
Alibangbang.	*Bauhinia malabarica.*
Pili.	*Canarium luzonicum.*
Oak.	*Quercus* sp.
Acacia, raintree.	*Enterolobium saman.*
Bulak, kapok.	*Ceiba pentandra.*
Tuba.	*Jatropha curcas.*
Bignay.	*Sporosa* sp.

Of the above list, the acacia, or raintree; kapok, or cotton tree; tuba; and bignay contain little or no tannin.

Although some of the others are low in tannin, their great abundance renders them of value to the tanner, especially in localities where there is no other tanning material. The chemical analyses of the barks are given in Table I.

TABLE I.—*Chemical analyses of some Philippine barks.*

[Numbers give percentages.]

Tree.	Moisture.	Calculated to dry basis.			Color of the infusions.
		Total extracts.	Tannins.	Nontannins.	
Pine, *Pinus insularis*	15.5	6.6	3.8	2.8	Wine red.
Narra, *Pterocarpus vidalianus*	15.1	41.9	30.7	11.2	Deep wine red.
Palo maria, *Calophyllum inophyllum.*	10.2	16.9	11.9	5.0	Wine red.
Alibangbang, *Bauhinia malabarica.*	12.4	22.8	9.5	13.3	Do.
Pili, *Canarium luzonicum*	11.3	11.2	7.8	3.4	Wine red with yellow tinge.
Oak, *Quercus* sp.	10.5	22.4	17.9	4.5	Deep wine red.

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[8] *This Journal, Sec. A* (1915), **10**, 349.

The reactions of the infusions with some reagents indicate that the extracts of pine and palo maria are similar in quality, notwithstanding the difference in quantitative analysis. The same qualitative similarity is found in the extracts of narra and pili barks. The qualitative tests are given in Table II. The action of the various infusions on delimed sheep skin is shown in Table III.

TABLE II.—*Reactions of the infusion of the barks with reagents.*

Bark.	Reagent.			
	Concentrated sulphuric acid.	Boiling diluted sulphuric acid.	Bromine water.	Ammonium ferric alum.
	Liquid.	*Precipitate.*	*Precipitate.*	*Precipitate.*
Pine	Yellowish brown or violet.	Reddish orange; difficultly soluble in alcohol and in boiling water.	Brown	Greenish black.
Narra	Yellowish brown.	Red; soluble in alcohol and in boiling water.	do	Reddish black or black with violet tinge.
Palo maria	Brown	Red; difficultly soluble in alcohol and in boiling water.	do	Greenish black.
Alibangbang			Whitish	Greenish brown.
Pili	Yellowish brown.	Reddish brown; soluble in alcohol and in boiling water.	Brownish yellow.	Brownish black or very dark brown with violet tinge.
Oak	do	Red; difficultly soluble in alcohol and in boiling water.	do	Green to bluish black.

TABLE III.—*Tanning effects of infusions of Philippine barks on delimed sheep skin.*

Bark.	Leather produced.
Pine	Satisfactory leather, of reddish tan, with firm texture and good grain. Tanning is slow.
Narra	Satisfactory leather, nut brown, with full, firm texture and good grain.
Palo maria	Satisfactory leather, similar to pine-tanned leather in color, texture, and grain.
Pili	Satisfactory leather; yellowish brown, firm texture, and good grain. Tanning is slow.
Oak	Light reddish brown leather, somewhat loose in texture and harsh in grain.

Like the bark of the majority of the Coniferæ[9] the bark of the Philippine pine (*Pinus insularis*) is low in tannin content.[10] However, the good quality of the leather produced and the availability of pine trees make it commercially important. The area of the pine forest is estimated at 518,000 hectares,[11] or 5 per cent of the public forest of the Philippines. The collection of bark should be easy, as the tree is used for lumber and at present the bark is waste. Whitford states that there is little doubt that, if fires were kept off, the pine (in the absence of broad-leaved competition) would quickly seed the entire area, for its reproduction is very rapid.

Pinus insularis has been investigated, but no work has been done on *Pinus merkusii*, which occurs in Mindoro[12] in pure stands and in open groves scattered throughout the grasslands, southwest of a high mountain mass. The samples used in this work were collected in the vicinity of Baguio, Benguet, by the Bureau of Forestry. They were 60 centimeters wide and 1.5 centimeters thick. The outside surface was dark gray, grooved, and scaly. This epidermal layer resembled cork; it contained no tanning principles. The inner surface was brownish and somewhat fibrous or woody.

Narra.—The bark of the narra tree has a fairly high tannin content and produces good leather. However, the timber is so widely scattered that it is doubtful if it will ever be available for tanning.

Pili.—The bark of this tree is suitable for tanning purposes and produces a satisfactory yellowish brown leather. However, it is not likely that this bark will be available on a commercial scale, because the tree produces valuable nuts and high-priced resin.[13] It is not abundant, nor is it systematically grown, and its propagation should be encouraged. The sample of bark collected in Ambos Camarines by the Bureau of Forestry was 2 millimeters thick; it was brown with white and gray cuticle. The inner surface was brown, brittle, and easily ground.

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[9] Procter's Principles of Leather Manufacture (1903), 246.

[10] Barks containing 3 to 15 per cent of catehol tannins are used in Styria, Austria, and in Russia. *Pinus cembra*, which grows in the Alps and which contains 3 to 5 per cent tannin, is used in Tyrol. The *pin sauvage* of France contains from 4 to 5 per cent. Hemlock bark, obtained from the hemlock fir which is abundant in the northern and western parts of the United States and in Canada, forms the staple tanning material of the United States [H. G. Bennett, Manufacture of Leather (1914), 136]. It contains from 8 to 11 per cent of tannin with much phlobaphenes.

[11] Whitford, H. N., *Bull. P. I. Bur. Forestry* (1911), No. 10, 17.

[12] Ibid., 31.

[13] Clover, A. M., *This Journal, Sec. A* (1907), 2, 1–40.

Palo maria de la playa.—The bark of *Calophyllum inophyllum* is suitable for tanning purposes. The species is more abundant than camanchili, and the trees are larger. It is widely distributed in the Philippine Islands, occupying a prominent place in the beach forests. The sample of bark taken at Pasay beach was 15 millimeters thick. It was brown with a decided yellow tinge and was divided into distinct ridges, many of which were broken into irregular, rectangular plates by cross fissures; the inner bark was pink or yellowish with concentric lines of a darker color.[14]

Oak.—According to Mr. E. D. Merrill,[15] botanist, Bureau of Science, there are about twenty-five species of Philippine oaks which grow at high altitudes in the mountains. The sample obtained by the Bureau of Forestry at Limay, Bataan, was 11 millimeters thick. The inner surface was dark red. The outer surface was lightly grooved and covered with a thin gray epidermis which contains no tannin. The bark is brittle and is easy to grind.

SUMMARY

At present only mangrove and camanchili bark are used for tanning in the Philippine Islands. A greater variety of barks is needed.

The Benguet pine and palo maria produce barks that can be used on a commercial scale. The latter surpasses camanchili in quality and availability. The barks of narra, pili, alibangbang, and oak were also studied. With the exception of the last two barks, all produced a leather with full, firm texture and good grain.

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[14] It has been pointed out by the Director of Forestry that while palo maria is much more abundant than camanchili the trees are widely scattered and the collection of bark from trees felled for lumber would be difficult and expensive. (EDITOR.)

[15] *This Journal, Sec. C* (1908), 3, 317.

POSSIBILITIES OF GULAMAN DAGAT AS A SUBSTITUTE FOR GELATIN IN FOOD[1]

By ALBERT H. WELLS

(From the Laboratory of Organic Chemistry, Bureau of Science, Manila, P. I.)

The seaweed *gulaman dagat,* a species of *Gracilaria,* is found growing throughout the Philippine Archipelago. During the first quarter of the year it is brought in to a limited extent by fishermen and is marketed as a food product. As a food it is used in two ways: (1) Washed free from salt water and boiled and eaten as a salad and (2) sun-bleached, dried, and marketed as a cheap substitute for gelatin. Its use and manufacture has not been exploited, and at present the local consumption is exceedingly small, due principally to the fact that a purer and whiter product has already been established in the market and is obtainable at a nominal price. This product is the Japanese gulaman, which is extensively used as agar-agar.

An investigation has been made with regard to the food value of gulaman dagat and to determine whether or not it could be used as a suitable substitute for gelatin. A food gelatin should stand tests showing a high percentage of purity and should be clear, only faintly colored, and quite odorless. It should have an excellent congealing strength.

A specimen of the seaweed was collected and identified as a species of *Gracilaria* by Mr. E. D. Merrill, botanist, Bureau of Science. After washing, boiling in water, and straining, the extract was cooled to a translucent greenish jelly. Another portion was washed free of salt and other foreign matter and was treated in the cold with very dilute acetic acid, after which it was washed, and dilute ammonia was added. It was again washed, and the residue was boiled for some time and strained through a suitable cloth. The extract was concentrated, and the jelly was dried. Three grams of the dry substance, made

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[1] Received for publication October, 1916.

in the manner described above, gave a strong jelly when treated with 300 grams of water and then boiled and cooled. This jelly had a higher melting point than true gelatin, thus resembling the gelose prepared by Payen[2] from *Gelideum corneum*. Another jelly having a dilution of 1 : 300 gave a firm jelly, having almost the consistency of ordinary gelatin as prepared for the table. This preparation melts in the mouth. However, it would seem that the ratio of 1 : 275 more nearly approximates the proper ratio for a jelly from gulaman dagat to be used as a food.

Gulaman dagat differs chemically from gelatin in that it is not an albuminoid. Gelatin contains approximately 17.9 per cent nitrogen, while gulaman dagat shows less than 1 per cent. It is equally low in all nutritive substances.

Analysis of the dry, prepared substance shows the following composition as compared with Japanese gulaman.

TABLE I.—*Analysis of gulaman.*

	Philippine.	Japanese.
	Per cent.	*Per cent.*
Moisture	16.00	19.60
Ether extract	1.20	1.08
Protein (N× 6.25)	4.20	4.23
Hydrolizable carbohydrate expressed as starch	35.39	29.65
Ash	4.00	2.90

Analysis of a firm jelly prepared in the laboratory showed the following:

TABLE II.—*Analysis of jelly from gulaman dagat.*

	Per cent.
Moisture	99.37
Ether extract	0.10
Protein	0.10
Ash	0.04
Starch	none
Carbohydrate by difference	0.39
	100.00

Many seaweeds after boiling yield a gelatinous extract which sets to a jelly. Table III shows the composition of various British algæ compared with that of gulaman dagat and the Japanese gulaman. Some of these are used as food and medicine.

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[2] Allen's Commercial Organic Analysis. P. Blakiston's Son & Co., Philadelphia (1914), 8, 622.

TABLE III.—*Comparison of gulaman with various seaweeds used for like purposes.*

	Water.	Nitrogen in dry substance.
British algæ:[a]	*Per cent.*	*Per cent.*
Chondrus crispus, bleached	17.92	1.534
Do	19.79	1.485
Chondrus crispus, unbleached	21.47	2.142
Do	19.96	2.510
Gigantina mamillosa	21.55	2.198
Laminaria digitata (dulse tangle)	21.38	1.588
Rhodymania palmata	16.56	3.465
Porphyra laciniata	17.41	4.680
Sarcophyllis edulis	19.61	3.088
Alaria esculenta	17.91	2.424
Japanese gulaman	19.60	0.806
Philippine gulaman dagat	16.00	0.800

[a] Thorpe's Dictionary of Applied Chemistry (1913).

It is evident that a jelly made from gulaman dagat would be of no appreciable value as a nutritive product. But it seems possible that gulaman dagat could be used in place of gelatin in food where a substance possessing only the physical qualities of gelatin is required. In other words, it could act as a carrier for flavors and fruit juices.

The suitability of gulaman dagat for agar-agar as a substitute for the Japanese gulaman has been worked out by Dr. H. Windsor Wade, bacteriologist, Bureau of Science. The physical characteristics of the extract were briefly noted by comparing them with those of ordinary agar-agar.

Extracts were made by soaking in cold water, boiling for considerable periods, and after rubbing through wire gauze filtering off the soluble portion through cheesecloth. Soaking the dried material, which is entirely filamentous, caused it to swell to two or three times its original bulk, the effect being apparently the same after two hours as after twenty-four hours. Using a proportion of 4 per cent of dry weed and replacing the water as evaporated, the extract obtained solidified on cooling and could be cast in the form of cakes which, with care, might be handled without breaking.

In order to compare the surface strength of this jelly with that of ordinary agar-agar of known concentration, a simple apparatus was devised with which the sustaining power of the uninjured surfaces of blocks of uniform size could be determined in terms of grams weight. Table IV gives the results obtained by averaging several tests. These figures are, of course, of value simply for comparison, since they apply only to the conditions of the experiment.

TABLE IV.—*Crushing pressure for agar-agar blocks.*

Emulsion No.	Agar-agar.	Room temperature, 28°C. (average of 3 tests).	Incubator temperature, 37°C. (average of 2 tests).
	Per cent.		
1	1.5	40-45 (?)	37
2	1.75	55.5	58.5
3	2.0	66	[a] 60
4	2.25	74	[a] 65
5	2.5	94.5	89.5

[a] Optimum.

Specimens 3 and 4 are particularly useful for bacteriological work; number 2 might be somewhat soft for use in planting water.

When the same test was applied to the gulaman extract, it was found that the surface strength was very slight, amounting to no more than from 5 to 8 grams. When, after prolonged boiling, the whole was passed through a sieve—in itself a very laborious process—and reboiled, the filtrate when cold gave pressure readings of but 9 to 10 grams. In addition to being very soft when cold, it appeared that an extract of this concentration, when still hot, was not freely fluid, but was stiff enough to interfere somewhat with cloth filtration.

With the intention of obtaining constant concentration of the extract, a quantity of the rubbed-through extract was dried to constant weight at incubator temperature. This gave a dark, hard, rather brittle material.

Upon attempting to redissolve this dried material, it was found that soaking for twenty-four hours restored a fragment approximately to its original size, but that even after this length of immersion, boiling rapidly for fifteen minutes effected only partial solution.

It was concluded that since the somewhat gelatinous extract of gulaman dagat resembles ordinary agar-agar, but does not have a similar peculiarly marked solidifying power, does not melt so freely, and is not so fluid when melted and solidified at a higher temperature, it is not suitable for use in bacteriological work.

SUMMARY

Gulaman dagat, a seaweed of the genus *Gracilaria* and found throughout the Philippine Islands, was investigated.

The conclusion was reached that it might serve as a substitute for gelatin where only the physical properties of gelatin are important, but that it is unsuitable for use in bacteriological work, owing to its low crushing pressure.

THE EFFECT OF SULPHIDE ON CEMENT[1]

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ONE PLATE AND 1 TEXT FIGURE

There has long been an opinion among cement users that no materials containing sulphur compounds should ever be utilized in making concrete.[2] Cases of failure have been reported which were attributed to sulphur compounds in some of the materials used or to sulphur compounds which came into contact with the finished construction.[3] According to Ljamin,[4] calcium sulphide, which is often present to a small extent in cement, has relatively little effect, though Kremann and Potts[5] mention potassium sulphide as an accelerator for the hydration of cement. There are so many factors, any one of which may be responsible for a failure, that it is often difficult to place the blame unless considerable research is carried on. It is known that cinders from certain sources are not satisfactory for concrete. This has been attributed to the sulphur in the coal burned. It is likely that some of the failures said to be due to sulphur compounds are caused by other agents, and vice versa.

A frequent source of sulphur compounds in concrete is the water used in mixing. In this case they are more uniformly distributed through the concrete than if present in the sand or aggregate. For these reasons the sodium sulphide used in the present work was added in the form of solutions. In most cases, where trouble is experienced from the presence of sulphur in the water used, it is likely that it is due to a mixture of several compounds. We might expect to find hydrogen sulphide, soluble metallic sulphides, sulphates, and possibly sulphites. It is obviously impossible to attempt the solution of a problem of this nature unless the effect of each substance is studied separately. It is our intention to carry on work along many of these lines. Work on the effect of sulphate on cement and

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[1] Received for publication May 10, 1916.

[2] This does not refer to the addition of a reasonable amount of gypsum to the cement for controlling the set.

[3] Borrowman, G., *Journ. Ind. & Eng. Chem.* (1912), 4, 405. Desch, C. H., The chemistry and testing of cement. Edward Arnold, London (1911), 75.

[4] Ljamin, N., *Journ. Soc. Chem. Ind.* (1902), 21, 972.

[5] Kremann, R., and Potts, H. E., The application of physicochemical theory to technical processes and manufacturing methods. D. van Nostrand Co., New York (1915), 161.

concrete is at present under way. There seems to have been little research done along these lines, except in studying the effect of various amounts of gypsum used in the manufacture of cement, especially where the concrete is subjected to the action of sea water. Many of the papers appearing in current journals are accounts of failures of concrete rather than the results of constructive research.

The general subject of the effect of sulphur compounds on concrete may be subdivided as follows:

1. The effect of sulphur compounds present in concrete which is exposed to normal conditions.

Borrowman[6] is of the opinion that sulphides and sulphates in cinders are sometimes largely responsible for failures of cinder concrete.

2. The effect of sulphur compounds present in concrete which is exposed to abnormal conditions, such as contact with sea water.

In some countries the idea is prevalent that a higher percentage of sulphuric anhydride is permissible in a cement used for ordinary construction than in one used for construction which is exposed to sea water. For example, France,[7] Japan,[8] and Argentina[9] have two specifications for sulphuric anhydride—a lower one for sea-water construction, and a higher one for ordinary construction.

3. The effect of sulphur compounds in liquids or gases which come into contact with concrete.

Rohland[10] reports the failure of a smokestack constructed of reënforced concrete, lined with bricks. The mortar between the bricks was made with a cement which was supposed to be acid-resisting. Sulphur compounds in the flue gases are blamed for the failure. The same writer[11] cites a case in which gases containing sulphur compounds had an injurious effect on the concrete in a tunnel. Sulphates in soil caused the failure of a concrete flower pot, according to Sartori,[12] and hydrogen sulphide in the waste water from a brewery caused considerable damage to a concrete sewer pipe.[13]

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[6] Loc. cit.

[7] *Ciment* (1912), **17**, 213.

[8] *Mitt. Zentralstell. Ford. Deut. Port. Zem. Ind.* (1912), **1**, 167.

[9] Ibid. (1912), **1**, 305.

[10] Rohland, P., *Feuerungstechnic* (1914), **2**, 360.

[11] *Beton u. Eisen* (1914), **13**, 341.

[12] Sartori, A., *Chem. Zeitg.* (1915), **39**, 957.

[13] Heyer, ibid. (1916), **40**, 102.

Renezeder[14] has carried on some experiments on the effect of sodium sulphide solutions on briquettes. He placed a number of briquettes, of both slag and Portland cement, in sodium sulphide solutions of various concentrations. Other briquettes of the same kind were kept in water for comparison. The test pieces were broken at the end of one, three, six, and twelve months, respectively. The briquettes which had been immersed in the sulphide solution were all weaker than the ones which had been kept in water. However, the writer states that if a briquette is kept in water for the first several weeks, and then placed in sulphide solution, no bad effects are noted.

The present work was undertaken in an effort to obtain data on the following points:

The concentration of sulphide which may be present in water used in making concrete, without causing any injurious effects.

The effect of sulphide solutions of accurately known concentrations on the setting time and tensile strengths of various cements.

Any chemical reactions which take place.

Since it was desired to make the work as comprehensive as possible, five barrels of cement, each of different brand, were purchased in the open market for the work. The brands chosen represent a wide range in method of manufacture and in composition. The contents of each barrel were thoroughly mixed. Samples of sufficient size to make the usual physical and chemical tests were taken, and the remainder was placed in large tin cans with tightly fitting covers and preserved until used. The five brands of cement will be referred to in this paper as A, B, C, D, and E. The chemical analyses are given in Table I; the physical tests, in Table II.

TABLE I.—*Chemical analyses of cements.*[a]

	A.	B.	C.	D.	E.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Loss on ignition	2.60	2.80	1.50	2.40	2.00
Insoluble residue	0.30	0.60	0.30	0.80	0.45
Silica (SiO_2)	21.10	20.00	22.50	18.80	18.95
Alumina (Al_2O_3)	8.76	8.86	7.58	9.18	9.52
Ferric oxide (Fe_2O_3)	1.42	1.34	1.12	1.12	1.38
Calcium oxide (CaO)	63.10	63.00	63.00	64.10	63.80
Magnesia (MgO)	1.26	1.34	1.74	1.12	1.80
Sulphuric anhydride (SO_3)	0.67	0.86	1.34	1.34	1.24
Potassium and sodium oxides (K_2O, Na_2O)	0.93	1.16	0.87	1.16	0.87

[a] Analyses by Francisco Peña, inorganic chemist; Bureau of Science.

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[14] Renezeder, H., ibid. (1907), **31**, 237.

TABLE II.—*Physical tests of cements.*[a]

Brand.	Fineness.		Specific gravity.	Soundness (five hours, in steam.)	Initial set.		Final set.		Tensile strength (neat). Kilos per square centimeter.[b]			
	Passing 200-mesh sieve.	Passing 100-mesh sieve.							1 day.	7 days.	28 days.	60 days.
	Per cent.	*Per cent.*			*Hrs.*	*min.*	*Hrs.*	*min.*				
A	87.6	99.0	3.12	O. K.	5	15	9	6	24.8	41.8	48.1	47.3
B	81.6	99.0	3.10	O. K.	3	55	6	40	23.6	43.5	45.7	45.7
C	89.6	99.0	3.16	O. K.	4	32	7	16	23.2	41.2	47.8	45.3
D	85.6	98.6	3.10	O. K.	4	26	7	4	24.5	44.5	50.7	47.5
E	88.2	99.0	3.10	O. K.	4	14	6	36	27.3	44.2	51.3	50.6

Brand.	Tensile strength (mortar). Kilos per square centimeter.				Tensile strength (neat). Pounds per square inch.				Tensile strength (mortar). Pounds per square inch.			
	1 day.	7 days.	28 days.	60 days.	1 day.	7 days.	28 days.	60 days.	1 day.	7 days.	28 days.	60 days.
A	7.0	16.8	23.4	25.3	353	595	685	673	100	238	333	360
B	7.0	17.5	21.7	22.8	337	617	651	649	100	248	308	325
C	9.3	19.8	26.7	30.1	330	586	679	644	133	282	380	428
D	8.7	20.8	28.8	30.9	348	633	722	677	124	294	409	441
E	10.8	23.2	28.5	29.1	388	628	731	720	154	331	407	414

[a] All physical tests were made in accordance with the specifications given in circular No. 33 of the United States Bureau of Standards.

[b] Each result represents the average of six briquettes.

PRELIMINARY WORK

An aqueous solution of hydrogen sulphide first suggested itself as the best source of the sulphide radical for the investigation, because it contains no metal which could cause complications. However, the idea was soon abandoned, for it was evident that sufficiently high concentrations of sulphide could not be obtained in such a solution, especially at the high average room temperature in Manila (30° C.). Therefore a soluble metallic sulphide (sodium sulphide) was chosen as being better suited for the work.

A sufficient quantity of sodium sulphide was obtained and analyzed. It was found to contain:

	Per cent.
Sodium (Na)	18.83
Sulphur as sulphate (SO_4)	0.34
Sulphur as sulphide (S)	11.93

After analysis, a quantity of this salt was dissolved in water to make a strong stock solution. The exact concentration of this solution was determined by analysis, and other solutions were made by dilution. The strength of each solution is given in terms of grams sulphur as sulphide per liter.

A cement which develops faults only after a considerable time has elapsed is worse than one which gives trouble in mixing. A cement which is quick-setting, or which is unsound in the boiling test, is, of course, rejected at once, while one which is satisfactory in the preliminary tests, but ultimately develops objectionable features, is not only valueless but dangerous, in that it may cause failure of the concrete in place.

Some former work[15] had shown that cement is very sensitive to the influence of sodium sulphide. With some of the solutions of higher cencentration employed at that time, a number of cements set so rapidly that briquettes could not be molded. Therefore in this work setting time tests were made first. The results are given in Table III.

TABLE III.—*Effect of various concentrations of sodium sulphide on the setting time of cements.*[a]

Sodium suphide added.		Initial set.										Final set.									
Sulpur (as sulphide) per liter of solution.[b]	Sulphur (as sulhide) per gram of cement.	A.		B.		C.		D.		E.		A.		B.		C.		D.		E.	
Grams.	*Per cent.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*	*H.*	*m.*
0.00	0.00	5	15	3	55	4	32	4	26	4	14	9	6	6	40	7	16	7	4	6	36
0.02	0.0004	6	60	6	2	6	25	5	32	4	22	17	10	13	55	13	55	14	29	9	55
0.11	0.0022	9	31	5	41	6	24	5	31	4	30	22	37	14	8	16	47	14	9	11	50
0.21	0.0046	6	56	5	59	7	11	6	39	4	33	14	39	12	4	12	7	12	24	8	53
0.43	0.0095	5	21	5	39	6	6	5	46	2	55	12	6	11	39	11	45	12	9	9	8
1.06	0.0233	5	54	5	2	5	37	4	54	2	51	12	32	11	17	11	20	11	39	8	11
2.13	0.0469	5	58	5	5	5	26	4	5	2	1	15	6	11	42	7	16	6	50	6	16
2.96	0.0651	5	38	5	46	5	8	3	35	1	1	14	16	9	11	6	58	6	35	5	21
5.93	0.1305	4	13	4	40	4	07	1	16	0	44	7	26	8	35	6	27	6	34	4	46
10.00	0.2200	1	42	4	44	4	44	1	3	0	35	5	38	7	49	7	49	3	1	3	5
20.00	0.4400	1	19	2	57	2	57	0	58	0	29	4	48	6	12	6	42	3	37	2	59

[a] Soundness tests were made, and each was found to be satisfactory.

[b] The concentrations of the solutions are given in terms of sulphur (as sulphide) per liter. The sulphate was determined, but was negligible.

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[15] Unpublished results obtained by Witt, J. C., and Baptie, J. A.

A study of Table III reveals that considerable change in both the initial and final set is caused by the sodium sulphide. The setting time is retarded by an addition of a small amount of sulphide, but is accelerated after a certain amount has been reached. For instance, with brand A the initial set is retarded from five hours and fifteen minutes to nine hours and thirty-one minutes, with the addition of 6.11 grams sulphide per liter; however, with the addition of 20 grams per liter, it is accelerated to one hour and nineteen minutes. The final set goes from nine hours and six minutes to twenty-two hours and thirty-seven minutes and then to four hours and forty-eight minutes, with the corresponding concentrations of sulphide. The table shows that brands A and E are the most sensitive to the effect of the sulphide; the former has the greatest range in setting time, while the latter shows the quickest initial and final set of all, that is, a sodium sulphide solution may either accelerate or retard the set, depending on the concentration. In every case the acceleration is greatest at some point between 0.02 and 0.21 gram per liter. As the quantity of sulphide becomes greater, the retarding influence increases until equilibrium is established. In most cases this point is between 0.43 and 5.93 grams sulphide per liter. The accelerating effect is supreme from this time on, and in general, the setting time is decreased with each increase in sulphide. However, after the concentration of 5.93 grams per liter is reached, further additions cause relatively small changes.

EFFECT OF HYDROGEN SULPHIDE

An experiment was carried on to determine whether or not the effect of sodium sulphide shown in the above experiments is due entirely to the sulphide radical or is partially attributable to the sodium present. To decide this, a solution of hydrogen sulphide was made by passing the gas into distilled water. Alliquot portions were removed and analyzed. The solution was found to contain 0.91 gram of sulphur per liter, present as sulphide. Setting time and soundness tests were made on the five brands of cement with this hydrogen sulphide solution. The results are similar to those obtained with the sodium sulphide solution having a sulphide concentration most nearly corresponding to that of this solution. All the soundness tests were satisfactory. The time of initial and final sets are given in Table IV.

TABLE IV.—*Effect of a solution of hydrogen sulphide on setting time of cements.*

Brand.	Initial set.						Final set.					
	Water only.[a]		Sodium sulphide. S= 1.06 grams per liter.[a]		Hydrogen sulphide solution. S= 0.91 gram per liter.		Water only.[a]		Sodium sulphide. S= 1.06 grams per liter.[a]		Hydrogen sulphide solution. S= 0.91 gram per liter.	
	Hrs.	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*
A	5	15	5	54	5	7	9	6	12	32	8	52
B	3	55	5	2	4	7	6	40	11	17	7	35
C	4	32	5	37	4	51	7	16	11	20	8	13
D	4	26	4	54	3	37	7	4	11	39	6	27
E	4	14	2	51	2	14	6	36	8	11	5	49

All soundness tests were satisfactory.

[a] These results were taken from Table III for the sake of comparison.

It is possible that in some of the higher concentrations of sodium sulphide solutions the sodium may have some influence, but for reasons already stated, a comparison with hydrogen sulphide cannot be made.

TENSILE STRENGTH TESTS

From the results given in Table III, the concentrations of the solutions for making the tensile strength specimens were decided on. A solution containing as much as 20 grams of sulphide per liter in some cases renders the cement quick-setting and causes trouble in making the briquettes properly. Therefore, to avoid any abnormalities in the briquette molding, it was decided to use no solution stronger than 10 grams per liter. The number of briquettes to be made with each cement and each solution was very large; consequently the number of solutions was limited to four. A stock solution was accordingly made to contain approximately 10 grams per liter. Portions were withdrawn from the stock bottle and diluted to give ½, ⅒, and $\frac{1}{100}$ of the original. The exact strength of each solution (by analysis) was as follows:

Solution 1 contained 9.70 grams sulphur, as sulphide, per liter; 2, 4.80 grams; 3, 0.97 gram; and 4, 0.097 gram.

Neat briquettes were made for the periods one, seven, twenty-eight, sixty, one hundred twenty, and one hundred eighty days; and for one, two, three, and five years. Mortar briquettes (one part cement to three parts Ottawa standard sand) were made for the same periods, except the one day. This paper covers only the results obtained during the first sixty days. The other briquettes are properly stored and will be broken when due. The results so far obtained are given in Table V.

TABLE V.—*Effect of sodium sulphide on the tensile strength.*[a]

NEAT CEMENT.

	Brand.	Kilos per square centimeter.					Pounds per square inch.				
		Solution.					Solution.				
		Water.	4	3	2	1	Water.	4	3	2	1
1 day	A	24.8	21.5	21.1	10.8	13.3	353	307	300	155	190
	B	23.6	28.8	27.3	23.9	18.4	337	411	388	340	262
	C	23.2	28.9	28.5	24.9	23.9	330	412	407	355	341
	D	24.5	23.5	21.7	15.1	17.9	348	335	308	214	255
	E	27.3	23.5	23.9	15.6	18.9	388	334	340	222	268
7 days	A	41.8	41.2	35.4	21.1	18.9	595	586	506	300	268
	B	43.5	43.7	40.8	33.3	32.3	617	622	579	475	460
	C	41.2	40.5	40.0	32.3	30.4	586	577	568	461	433
	D	44.5	41.3	39.0	32.7	38.9	633	587	554	467	553
	E	44.2	44.9	42.9	31.9	36.5	628	638	609	456	519
28 days	A	48.1	45.1	38.6	40.3	27.4	685	642	548	573	391
	B	45.7	42.9	42.2	39.8	34.7	651	611	599	567	495
	C	47.8	44.4	42.5	31.7	28.8	679	632	605	452	410
	D	50.7	50.9	46.0	44.3	41.2	722	726	655	630	584
	E	51.3	51.6	45.3	41.4	37.9	731	736	645	588	539
60 days	A	47.3	42.5	38.0	39.4	28.4	673	606	542	560	406
	B	45.7	43.5	40.8	40.1	36.8	649	618	581	569	526
	C	45.3	46.7	47.4	35.3	28.1	644	666	676	503	400
	D	47.5	48.1	45.1	40.8	41.1	677	685	642	581	584
	E	50.6	47.4	42.3	41.5	36.1	720	676	602	589	516
MORTAR.											
7 days	A	16.8	14.8	12.2	16.5	5.2	238	209	174	234	74
	B	17.5	16.4	16.2	12.2	10.1	248	233	230	174	145
	C	19.8	17.8	17.5	12.2	11.8	282	253	248	174	168
	D	20.8	16.9	16.9	11.3	10.1	294	239	240	162	144
	E	23.2	18.6	26.2	12.6	10.9	331	265	374	179	157
28 days	A	23.4	20.5	16.6	16.9	8.7	333	292	237	240	124
	B	21.7	19.7	18.2	17.7	15.4	308	280	258	252	218
	C	26.7	25.0	21.4	10.8	17.6	380	357	305	155	251
	D	28.8	24.1	23.2	16.6	15.8	409	343	329	237	226
	E	28.5	22.5	21.4	19.7	15.9	407	319	304	279	227
60 days	A	25.3	21.1	22.5	19.9	18.2	360	299	320	283	258
	B	22.8	28.1	26.8	20.4	18.3	325	399	382	290	259
	C	30.1	22.4	20.4	14.3	10.9	428	318	290	205	157
	D	30.9	26.9	24.5	20.3	18.6	441	383	348	288	265
	E	29.1	24.2	24.6	18.7	17.6	414	344	351	267	249

[a] Each result shown is the average of six briquettes.

A comparison of the results reveals that there is a considerable decrease in strength, caused by sulphide solutions. In general, this decrease seems to be approximately proportional to the concentration of sulphide in the solution used. It is also apparent that brands A and E are again most affected by the sulphide. The broken briquettes appear normal in every respect except in color; there is no swelling, cracking, nor distortion. Table V shows that the average loss in tensile strength caused by using a given sulphide solution in place of water is greatest with the cement highest in iron.

CEMENT HIGH IN IRON CONTENT

In order to determine how far the relationship between iron content and tensile strength might hold, briquettes were made from two other samples of cement much higher in iron. These were designated as F and G. Sample F was a brand of cement different from any other used in this work. It contained 3.44 per cent iron oxide (Fe_2O_3). There was no cement of still higher iron content available, so sample G was made by grinding iron oxide to pass a 100-mesh sieve and by intimately mixing a given weight with a portion of sample F. This added iron oxide could not be considered as a part of the cement, but was present as a foreign substance. The experiment was carried on with the object of determining whether or not there was any relation between the effect of iron which was an integral part of the cement and iron which was added to the finished product.

The tensile strengths of samples F and G are shown in Table VI.

TABLE VI.—*Effect of sulphide on cement high in iron content.*

Sample.	Total ferric oxide (Fe_2O_3) in dry cement.	Tensile strength.[c]										Setting time.	
		Kilos per square centimeter.					Pounds per square inches.						
		Neat.			Mortar.		Neat.		Mortar.				
		1 day	7 days	28 days	7 days	28 days	1 day	7 days	28 days	7 days	28 days	Initial.	Final.
	Per cent.											*Hrs. min.*	*Hrs. min.*
F[a]	3.44	29.6	48.1	42.9	17.3	28.0	423	685	611	247	398	2 47	5 15
F[b]		15.3	23.9	23.2	14.3	17.6	218	341	330	204	250	2 2	5 24
G[a]	8.63	24.1	38.7	41.2	19.7	24.5	343	550	586	279	348	3 59	5 41
G[b]		12.6	20.4	18.3	11.6	15.5	180	291	261	162	221	2 47	6 42

[a] Gauged with water.
[b] Gauged with solution 1.
[c] Each result represents the average of three briquettes.
Soundness tests were made with both water and solution 1. All were satisfactory.

The results show that the relation between iron content and loss in tensile strength continues for sample F, although the relative loss is not so great as with the five cements previously tested. Apparently the added iron oxide in sample G has little effect as far as the sulphide is concerned, but causes a lowering of the tensile strength as any foreign substance is likely to do. The fact that the added iron is not so finely divided nor so uniformly distributed as that originally present no doubt partly accounts for the difference in behavior.

PERCENTAGE LOSS IN TENSILE STRENGTH

It is evident that in comparing the loss in tensile strength with the iron content of the cements and with concentrations of the sulphide solutions, the percentage loss should be the true basis of comparison. Accordingly Tables VII and VIII have been prepared. Table VII shows the percentage loss in tensile strength for the cements of various iron content when gauged with the sulphide solution having the highest concentration (No.1). Table VIII shows the percentage loss in tensile strength of brand A when gauged with sulphide solutions of various concentrations. This brand has the highest iron content of any of the cements studied in detail. The values given in these two tables may be taken in general as typical of the tensile strength results, although some of them are not so regular. This can be understood by remembering that a great many factors other than the iron content and sulphide concentration influence the strength of these briquettes. In general, the relation between percentage loss in tensile strength and iron content is not so well established with the mortar briquettes as with the neat briquettes.

TABLE VII.—*An example of variation of percentage loss in tensile strength with the iron content.*

Brand.	Iron oxide (Fe_2O_3).	Tensile strength in kilos per square centimeter.[a]		Tensile strength in pounds per square inch.		Loss in tensile strength in kilos per sq. cm.	Percentage loss.
		With water.	With solution No. 1.	With water.	With solution No. 1.		
	Per cent.						
D	1.12	50.6	41.2	722	584	9.4	18.58
B	1.34	45.7	34.7	651	495	11.0	24.07
E	1.38	51.3	37.9	731	539	13.4	26.12
A	1.42	48.1	27.4	685	391	20.7	42.62
F	3.44	48.1	23.9	685	341	24.2	50.31
G	8.63	38.7	20.4	550	291	18.3	47.29

[a] All briquettes were made of neat cement and broken at the end of seven days. Brand C shows irregular results, and since it has the same iron content as brand D, the results have been omitted here.

TABLE VIII.—*An example of variation in percentage loss in tensile strength with concentration of sulphide.*

Solution No.	Sulphide per liter.	Tensile strength.[a]		Loss in tensile strength.	Percentage loss.
		Per square centimeter.	Per square inch.		
	Grams.	*Kilos.*	*Pounds.*	*Kilos.*	
Water only		41.8	595		
4	0.097	41.2	586	0.6	1.43
3	0.97	35.4	506	6.4	15.31
2	4.80	21.1	300	20.7	49.52
1	9.70	18.9	268	22.9	54.78

[a] All briquettes were made of neat cement (brand A) and broken at the end of seven days.

The variation in percentage loss in tensile strength is also shown in fig. 1.

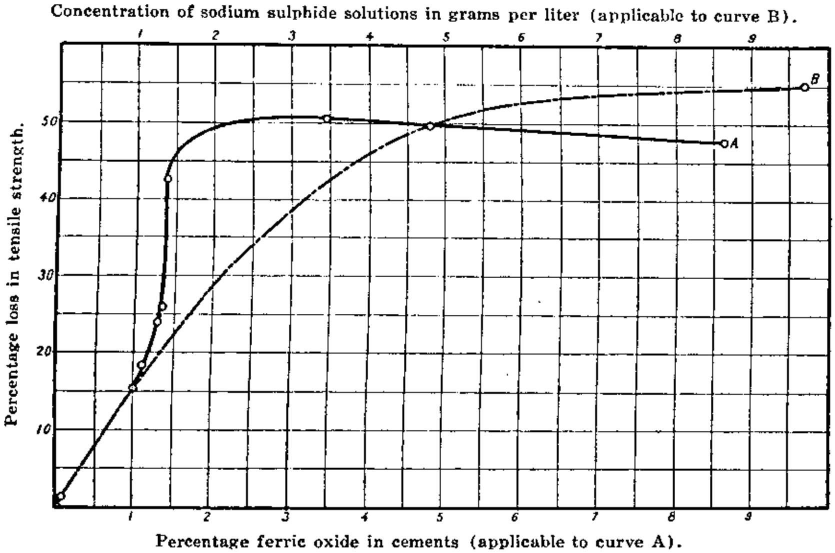

Fig. 1. Examples of variation of percentage loss in tensile strength with the iron content of cements (curve A and with the concentration of sulphide solutions (curve B).

A STUDY OF THE CHEMISTRY INVOLVED

In preparing the test pieces after the solutions of higher concentrations had been reacted, it was noticed that there was an abnormal rise in temperature and that the mixture turned green. Some of the cements showed these characteristics in a greater degree than others. The color was much lighter when the briquettes and pats were dry—becoming light bluish green. It seemed very likely that the production of color was connected with the effect of the sulphide on cement and, accordingly, an effort was made to determine its cause. The briquettes, in a measure, retained the green color even until the time of breaking, but is was noticed that the color was more intense in the interior than on the surface.

The distribution of the colored areas is shown in Plate I. Broken briquettes were selected at random, ground square on an emery wheel, and photographed while wet. The section shown is at the point of fracture. The briquettes were broken at the end of twenty-eight days, and were gauged with solution No. 1, containing 9.70 grams sulphide per liter. The upper two are neat briquettes, and the lower two, mortar briquettes. Nos. 1 and 3 contain no sulphide; they were photographed simply for comparison. It is interesting to note the irregular distribution of the color in the mortar and the fairly uniform distribution in the neat cement.

The boiling pats lost the color on the upper surface, which was exposed to the steam, but the surface which remained next the glass plate and the interior retained the color. In order to demonstrate that the color was not produced by the action of the sulphide on the steel trowels, or on some foreign substance about the mixing table, some of the cement was mixed with a sulphide solution, where the mixtures came in contact with nothing but a glass plate and a porcelain spatula. The color appeared as before. Since iron is the only element present, in any quantity, which is known to give a dark-colored sulphur compound, it was believed to be involved in the reaction. This idea was strengthened by the fact that de Koninck and Ledant[16] report the formation of a bright green on treating iron salts with sodium or potassium polysulphide. The first effort to determine the factors in the reaction was as follows:

Brand E, which is one of the most sensitive of the cements under consideration to the influence of sulphide, as shown in both the setting and the tensile-strength test, was chosen for the preliminary work. Accurately weighed 5-gram duplicate portions of the cement were placed in beakers. Ten cubic centimeters of a sulphide solution, the analysis of which was known, were added; after thoroughly mixing, hot water was added and the mixture was stirred. After settling, the cement was separated from the supernatant liquid and washed until the wash water showed no further tests for sulphide. The filtrates and washing were allowed to cool and were made up to definite volumes. Alliquot portions, equivalent to 1 cubic centimeter of the original sulphide solution, were removed and titrated with ammoniacal zinc chloride solution. Some of the original sulphide solution was titrated at the same time, so that the change in the concentration of the sulphide in the two solutions could be calculated. The results are shown in Table IX.

---

[16] De Koninck, L. L., and Ledant, M., *Zeitschr. f. angew. Chem.* (1891), 202.

TABLE IX.—*Analysis of sulphide solution before and after contact with cement.*

Solution.	Zinc solution required per cubic centimeter of sulphide solution.	Sulphur as sulphide per cubic centimeter.	Sulphur as sulphide removed by cement.
	cc.	*Grams.*	*Grams.*
Original	27.10	0.0422	
After mixing with 0.5 gram cement	25.37	0.0396	0.0026

Although the green color caused by adding the sulphide solution to the cement appeared almost immediately, the above results show that only 6.16 per cent of the sulphide was removed from solution, either by oxidation or by the formation of an insoluble compound. Considerable calcium and a trace of magnesium went into solution. (Further test indicated that the presence of the sulphide did not increase the solubility of the calcium hydroxide.) The results were verified by mixing some cement of known sulphate content with sulphide solution and allowing to stand overnight. On analysis it was found that there was a slight increase in sulphate.

The preliminary experiments were carried out in contact with the air, and it seemed likely that this might account for some of the oxidation that took place. Moreover it was noticed that the carbon dioxide in the air interfered by converting some of the dissolved calcium hydroxide into carbonate. Consequently the next experiments were made in an atmosphere of hydrogen.

Five hundred cubic centimeters of water were placed into each of two 750-cubic centimeter Erlenmeyer flasks. The flasks were fitted with reflux condensers, and the water was boiled from one to two hours to remove the air. The flame was then removed, and a stream of hydrogen was passed through the water until it had cooled to room temperature. Two 5-gram portions of freshly ignited cement were then weighed and placed in small glass capsules. One of the capsules was added to the first flask while a stream of hydrogen was passing, so that no air entered the flask, and immediately a solid rubber stopper was placed in the neck. To the other capsule containing the cement 2.5 cubic centimeters of sulphide solution were added from a burette, after which the whole was added to the second flask, observing the same precaution as before. After shaking vigorously to break up any lumps, the two flasks were placed in a mechanical shaker and violently agitated for twenty-four hours. Fifty cubic centimeter portions were withdrawn, while a stream of hydrogen was passing, and the sulphate was determined. The results indicated that a very small amount of the sulphide was oxidized.

According to Desch,[17] ferrous sulphate may be formed in a cement by the action of a sulphide, provided ferrous iron is present. He says:

> Calcium sulphide, CaS, is often present to a very small extent in cements, and is then derived from the reducing action of the fuel on calcium sulphate contained in the raw materials or formed, in a stationary kiln, from sulphur compounds in the fuel. Calcium sulphide is more characteristic, however, of blast furnace slags. If the cement contains ferrous iron, this is converted into the green ferrous sulphide which is generally considered to be objectionable from its liability to undergo oxidation accompanied by expansion of volume.

While ferrous sulphate may be formed in some cements under the above conditions, I believe it is not frequently formed in quantities sufficient to cause trouble—certainly not in any of the cements studied in the present investigation. The green color produced by sodium sulphide solution is misleading because it suggests the presence of ferrous sulphate, whereas various tests have shown that no appreciable amount of this compound is formed.

REACTION BETWEEN IRON OXIDE AND SODIUM SULPHIDE

With the object of obtaining further information on the formation of the green color, ferric oxide was treated with 10 per cent sodium sulphide solution. After a few minutes the mixture commenced to darken; on warming on the hot plate the red color disappeared entirely, and an examination showed that the particles had become coated with a dark film. To study the reaction further, weighed portions of ferric oxide were treated with known volumes of the sulphide solution. Blanks containing no iron were run for comparison. Each was made up to a definite volume, and portions were removed for titration. The results are given in terms of grams sulphur, as sulphide, per cubic centimeter of sodium sulphide solution.

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[17] Loc. cit.

Sulphur per cubic centimeter—	Gram.
In original solution	0.0460
In blank after warming	0.0240
After warming with iron oxide	0.0090

The ferric oxide, therefore, removed 0.0150 gram sulphur from each cubic centimeter of solution. The total iron present was 0.3500 gram. The total sulphur removed was 0.1500 gram.

It was apparent that not all of the ferric oxide had been attached by the sulphide. The film which formed around each small particle protected the interior, and the action stopped as soon as mechanical equilibrium (*Mechanisch Labil*[18]) was established.

The black substance was insoluble in the sulphide solution and was filtered out with the unconverted oxide for the purpose of examining its composition. However, on attempting to wash it with water, it produced a dark green, slightly turbid solution. More of the substance has been prepared, and its behavior has been studied. The results indicate that it is a colloid. The substance may be precipitated by a number of electrolytes, among which are sodium sulphide, calcium hydroxide, and sodium sulphate. On this basis both chemical and physical tests point to the following explanation:

When cement is gauged with a sodium sulphide solution, the sulphide acts with the iron in the cement and forms a colloid, which may be percipitated by dissolved calcium hydroxide or by excess sodium sulphide present. Some of the calcium hydroxide is removed from solution by adsorption, and possibly some is directly precipitated by the sodium sulphide. This is no doubt largely responsible for the decrease in tensile strength. It is in harmony with the work of Renezeder[19] previously mentioned. After a cement briquette has fully hardened, the sulphide solution cannot reach a sufficient amount of the iron to cause any noticeable effect, except after a long period of time, although it does react with the iron at the surface.

CONCLUSIONS

While the results of this investigation are not directly applicable to every cement on the market, they may serve as a guide in predicting the effect of a sulphide solution on a given cement.

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[18] Vide Cox, Alvin J., *Zeitschr. f. anorg. Chem.* (1904), 40, 174.

[19] Loc. cit.

1. The setting time of a cement is greatly modified by the presence of sodium sulphide. With low concentrations the set is retarded, but after reaching a maximum, further additions accelerate the set. In general, the cements highest in iron content are most sensitive to this influence.

2. There is a decided decrease in tensile strength.[20] The percentage loss varies with the concentration of the sulphide and with the iron content of the cement. The briquettes appear normal in every other respect, except in color. There is no cracking nor distortion of any sort.

3. In most cases sulphide may be present in concentrations up to 1 gram per liter without causing the tensile strength to fall below United States Government specifications.

4. Certain results indicate that a colloid is formed by the action of sodium sulphide on the iron in the cement.

5. Based on the results of both chemical and physical observations, the following explanations of the decrease in tensile strength are offered:

(*a*) The precipitated colloid forms films of inert material through the cement and interferes with the cohesion.

(*b*) When the colloid is precipitated a portion of the dissolved calcium hydroxide is removed from solution. Since the latter substance is a very important factor in the strength of cement, it is to be anticipated that the strength will be lowered, when some of it is removed.

6. It is probable that a number of other factors influence the effect of sulphide on cement. Among these may be mentioned the fineness of the cement, the temperature at which it is mixed, the percentage of water used, and the amount of dissolved calcium hydroxide.

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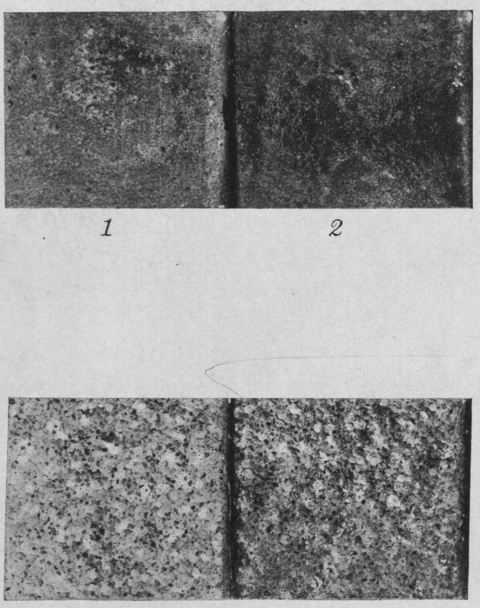
[20] The only specimens yet broken are those during the first sixty days.

ILLUSTRATIONS

PLATE I. Colored areas in briquettes caused by presence of sodium sulphide.

TEXT FIGURE

FIG. 1. Curves showing examples of variation of percentage loss in tensile strength with the iron centent of cements and omits the concentration of sulphide solutions.



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3 4

PLATE I. COLORED AREAS IN BRIQUETTES CAUSED BY PRESENCE OF SODIUM SULPHIDE.

NOTE ON THE BLACHER METHOD FOR THE DETERMINATION OF HARDNESS IN WATER[1]

By A. S. BEHRMAN

(*From the Laboratory of General, Inorganic, and Physical Chemistry, Bureau of Science, Manila, P. I.*)

Because of the large amounts of free carbon dioxide and sodium chloride often found in Philippine waters, a study was made of the influence of these substances in the determination of hardness of water by the Blacher method,[2] as such data are not available in the literature. Attention was also directed to certain details of manipulation. Briefly summarized, the results of this study were as follows:

1. *Effect of free carbon dioxide.*—The presence of large amounts of free carbon dioxide causes incorrect results in the determination of temporary hardness, as well as an indistinct end point, with correspondingly incorrect results, for the "total hardness." Satisfactory results were obtained with concentrations as high as 28 parts of free carbon dioxide per million, and it is possible that even this figure might have been exceeded without introducing any great error, though no attempt was made to find the exact limiting concentration possible. Twenty-five parts per million may be regarded as a safe maximum. Even with very high initial concentration, aspiration of five to ten minutes was sufficient to bring the quantity of free carbon dioxide below this limit.

2. *Removal of carbon dioxide.*—Boiling the solution for from five to ten minutes to remove carbon dioxide, as advised by several investigators, before titrating with potassium palmitate, was found to have no more beneficial effect than aspiration for five minutes.

3. *Effect of salt.*—Sodium chloride in the amounts normally found in natural waters has no effect on the results. Concentrations varying from 10 to 2,000 parts per million of chlorine were employed, without perceptibly affecting the end point.

4. *Dilution of very hard water.*—If the total hardness (as

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[1] Received for publication October 2, 1916.

[2] Blacher C., Grunberg, P., and Kissa, M., *Chem. Zeitg.* (1913), 37, 56–8.

calcium carbonate) is much over 250 parts per million, it may be found convenient to dilute a water sample with distilled water to prevent the heavy precipitate from obscuring the end point. A 100 cubic centimeter sample may be diluted to at least 500 cubic centimeters with distilled water, without appreciably affecting the end point.

5. *Distinction of end points.*—An effort was made to distinguish the three end points mentioned by Herbig,[3] namely, a very faint red, followed by a light red, followed by an intense red, the last of which, Herbig states, is the one to be used in almost all cases, particularly in waters high in magnesium. With solutions containing only calcium, the first two end points lie very close together, so that either could be taken as the true end point and give results well within the limits of experimental error. With solutions containing considerable amounts of magnesium, the first end point was reached long before a value corresponding to the true end point was obtained. Additions of potassium palmitate after the second end point had been reached produced deepening of the phenolphthalein coloration, apparently corresponding simply to successive transformations of additional amounts of indicator. No sharp transition point was observed, so that the third end point mentioned by Herbig could not be located.

By taking the second end point, mentioned in the preceding paragraph, very satisfactory results were obtained, whether the hardness of water was caused by calcium or by magnesium, singly or combined. Determinations made in a considerable number of both artificially prepared and natural waters, checked by gravimetric determinations, showed an average variation of 2 to 3 per cent from the true calcium and magnesium content—a degree of accuracy comparable with that obtained by J. Zink and F. Hollandt,[4] and by E. Nochmann.[5]

Using these data as the basis of any deviation from Blacher's original procedure, the method as finally adopted is as follows:

A 0.1 *N* potassium palmitate solution is prepared, according to the method given by Herbig[6] for potassium stearate, by the neutralization of palmitic acid in alcoholic glycerol solution. This solution is standardized against a saturated solution of calcium hydroxide.[7]

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[3] Herbig, W., *Farber Zeitg.* (1913), 24, 98-101.

[4] *Zeitschr. f. angew. Chem.* (1914), 27, 1, 439.

[5] *Pharm. Zentralh.* (1914), 55, 436-7.

[6] *Farber Zeitg.* (1913), 24, 113-4.

[7] Blacher et al, loc. cit.

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[3] Herbig, W., *Farber Zeitg.* (1913), **24**, 98-101.

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[5] *Pharm. Zentralh.* (1914), **55**, 436-7.

[6] *Farber Zeitg.* (1913), **24**, 113-4.

[7] Blacher et al, loc. cit.

REVIEWS

How to make | low-pressure | transformers | second edition | with additions | by | Prof. F. E. Austin, Hanover, N. H. | [6 lines] | copyright 1915, by F. E. Austin | Hanover, N. H. | Cloth, pp. 1–17. Price, $0.40.

This small book, while of no value to engineers or advanced students, gives full instruction for the construction of a small-capacity experimental transformer which should be useful to all young experimenters.

J. C. ROCKWELL.

Examples | in | alternating-currents | vol. I. | second edition | with additions | for | students and engineers | by | F. E. Austin, B. S., E. E. | [5 lines] | Hanover, N. H. | 1916 | Flexible leather, pp. 1–223. Price, $2.40.

The volume of examples in alternating-currents with its illustrative problems and condensed tables should be an excellent aid to students, as it covers the subject in a brief and concise manner and links together theory and practice in a way not found in the usual textbooks used for instruction. Engineers, also, will find it very useful, particularly those who have only occasional problems to solve which require mathematics, as calculus and its applications are easily forgotten when seldom used.

J. C. ROCKWELL.

Examples in magnetism | second edition | for students of | physics and engineering | by | Professor F. E. Austin, B. S., E. E. | [5 lines] | Hanover, N. H. | 1916 | Flexible leather, pp. 1–90. Price, $1.10.

The author has carefully laid his foundations for the subject by reviewing briefly, but thoroughly, the necessary parts of trigonometry and mechanics. He then presents his examples worked out in full and enough of them to give the student a good idea of the theory and application of magnetism.

J. C. ROCKWELL.

Directions for | designing, making, and | operating | high-pressure transformers | by | Professor F. E. Austin | copyright 1914 by F. E. Austin | [6 lines] | printed by | The Capital City Press | Montpelier, Vt. | Cloth, pp. 1–46. Price, $0.65.

The title of this book is misleading, as it treats of but a small part of the considerations necessary in high-pressure transformer design, manufacture, and operation. With the aid of this book, however, the student can learn a great deal concerning both theory and practice.

J. C. ROCKWELL.

Ernährungsphysiologisches | Praktikum der höheren Pflanzen. | von | Dr. Viktor Grafe, | a. o. Professor an der Universität in Wien. | [ornament] | Mit 186 Textabbildungen | Berlin | Verlagsbuchhandlung Paul Parey | Verlag für Landwirtschaft, Gartenbau und Forstwesen | S. W. 112, Hedemannstrasse 10 u. 11 | 1914. | Cloth, i–x+1–494. Price, 17 marks.

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  Austin, F. E., How to make low-pressure transformers, 295.
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